The Reality of the use of Virtual Laboratories and its Relationship to Students' Scientific Thinking Skills Thought Innovations in Education Techniques from the Point of View of Faculty Members in Some Saudi universities

By

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Abstract:

The current study aimed to investigate the reality of the use of virtual laboratories and its relationship to students' scientific thinking skills in light of innovations in educational technologies from the point of view of faculty members in some Saudi universities.

The study sample included (285) faculty members in some Saudi universities. The researcher used the descriptive analytical approach based on the questionnaire to achieve the objectives of the study. The study reached many findings, the most important of which were: that "the degree of possessing scientific thinking skills among students in light of innovations in educational technologies from the point of view of faculty members in some Saudi universities" was (moderate); and that "the reality of using virtual laboratories in Saudi universities in light of the innovations in educational technologies" came with a (moderate) degree from the point of view of the faculty members of the study sample; The study also revealed that there is a positive correlation between the total degree of using virtual laboratories and the degree of students' scientific thinking skills from the point of view of faculty members in some Saudi universities, as it reached (.885**).

The researcher provided several recommendations in light of the findings, the most important of which were: working on developing and updating means and technologies in virtual laboratories with the aim of enhancing the learning process and delivering information easily to university students; and the need for faculty members to provide students with the skills of aligning the innovative idea with the prevailing values in society and with their previous experiences.

Keywords: Virtual Laboratories – Scientific thinking – Saudi Universities.

Introduction:

The current era is witnessing many rapid and successive developments and changes in all fields and at all levels, and the Kingdom of Saudi Arabia has sought in various ways to have an abundance of these developments, especially in the field of education, as it has spared no effort to reform and improve all educational institutions at all stages, especially universities, to produce a technical generation that can deal with reality with the latest means and technologies.

Technological progress has led to the emergence of new methods and ways of indirect education, which depend on employing technological innovations to achieve the required learning, including the use of computers and their innovations, satellites and satellite channels, and the global information network, in order to provide learning all day and all night along for whoever wants it, and wherever they want it, through various methods supported by innovations in educational technologies with its various components, to present educational content through the combination of written language with spoken language, static and animated visual elements, and various audio and visual effects and backgrounds, which are displayed to the learner through the computer, which makes learning interesting and enjoyable, and is achieved in the highest efficiency, with minimum effort and time, which achieves quality education, and among the most important innovations that are being used today in Saudi universities are virtual laboratories. (Center for Developing University Education, 2017, p. 631)

One of the most prominent educational developments emerging from technological progress is what is known as virtual laboratories. Virtual laboratories provide students with skill experiences that are very close to direct experience, away from the danger resulting from the practice of some experiments in direct ways. They also eliminate the obstacles that prevent the practice of real experiments, such as the lack of equipment, time and space factors, or extreme accuracy of the studied subject; In addition, they increase the ability of students to visualize concepts that are difficult to imagine realistically, and they can also provide an interesting scientific environment by practicing the experiment step by step and giving feedback and the possibility of following up on the work accomplished by students, and through it, it is possible to replace some equipment that is difficult to find in school laboratories, as virtual laboratories enable students to study the composition and reproduction of bacteria and viruses in an interactive way without studying them using an electron microscope. (Al-Janabi, 2015, p. 451)

Virtual education meets the tendencies of the current generation, which is described as a (Virtual Generation); It is a generation that is proficient in dealing with digital technology and learns quickly from it. It also enables learners who tend to e-learning style to learn outside school times and achieve the principle of self- and continuous learning, and allows them to build their own knowledge by placing them in open and active learning environments rich in learning resources. (Belfaqih, 2020, p. 237-238)

The use of virtual laboratories provides the students with the opportunity to become familiar with new strategies in learning that support higher-level skills such as communication, information literacy, self-management skills, problem-solving, self-study, cooperative learning, and so on (Gunawan et al., 2018).

The virtual lab is characterized by efficiency in developing various scientific thinking skill, as the virtual lab is effective and efficient in developing higher thinking skills, including scientific thinking skills, in addition to raising the level of achievement in academic concepts among students, in addition to the effect of the virtual lab in increasing students' motivation to learn (Ambusaidi et al., 2018).

Practicing scientific thinking skills is one useful solution for improving students' skills in using information and communication technologies in society, therefore, empowering students' scientific thinking skills is very important in learning nowadays. Scientific thinking skills frequently deal with the method of observing, recording, describing, questioning, explaining, and arriving at a conclusion (Asmoro et al., 2021).

From the above, it is clear to the researcher the importance of using virtual laboratories as a means of developing students' skills, most importantly are scientific thinking skills. Virtual laboratories provide unique opportunities for teaching and learning, as they allow learning in virtual environments similar to real ones, but with the possibility of incorporating additional elements and being free from the constraints of time and space. And by using the costly capabilities, the students develop various skills, the most important of which are scientific thinking skills, which are one of the important ingredients for adapting to the requirements of life in 21st century societies.

Study problem:

Educational sectors witnessed a great development as a result of the tremendous development in educational technologies and information and communication. One of the most prominent manifestations of this development is the introduction of many new educational technologies, the most prominent of which are virtual laboratory technologies; Through the use of virtual laboratories, students can develop many skills, including scientific thinking skills.

Several studies have addressed the positive effects of virtual laboratories on students. For example, Al-Zahrani's (2020) study showed a positive correlation between the use of virtual laboratories and the levels of students' scientific thinking skills; These findings are consistent with the findings of Al-Shehri (2018) study, which explained this positive correlation with the ability of virtual laboratories to simplify information and theoretical concepts for students.

In spite of the promising benefits of using virtual laboratories, their use is surrounded by many challenges and obstacles. As indicated by Mohammad's study (2021), the use of virtual laboratories may be surrounded by obstacles that include the unavailability of internet services at the university, and poor design in terms of effort and time requirements; As for the study of (Alshaikh, 2022), it sheds light on other obstacles to the use of virtual laboratories in educational contexts, and these obstacles include the large number of students, the need to increase the number of working hours and the amount of administrative tasks, insufficient necessary equipment, and weak motivation among students.

Hence the importance of highlighting the role that virtual laboratories can play in Saudi universities to address the shortcomings in students' scientific thinking skills in light of the innovations in educational technologies, as these laboratories contribute to creating an attractive and interesting environment for learning with minimal effort and cost. In addition, they are less dangerous, as learners can conduct experiments without any damage, and given the importance of scientific thinking skills among students and the importance of possessing them for individuals, modern technological means have contributed to the development and improvement of these skills, which is beneficial to university students, and thus to universities, and then to the institutions of the entire society, given the possibility of graduating a generation capable of keeping pace with changes and contributing to their development through innovative and creative thinking. Hence the importance of investigating the role of virtual laboratories and technological innovations within Saudi universities. The problem of the study can be highlighted through the following main question: (Is there a correlation between the use of virtual laboratories and the enhancement of students' scientific thinking skills in light of innovations in educational technologies from the point of view of faculty members in some Saudi universities)?

Study questions:

- What are the levels of scientific thinking skills among students in light of innovations in educational technologies from the point of view of faculty members in some Saudi universities?
- What is the reality of using virtual laboratories in light of the developments in educational technologies from the point of view of faculty members in some Saudi universities?
- Is there a statistically significant correlation at the level (0.05) between the total score of using virtual laboratories and the score of students' thinking skills from the point of view of faculty members in some Saudi universities?

Study objectives:

- Investigating the levels of scientific thinking skills among students in light of innovations in educational technologies from the point of view of faculty members in some Saudi universities.
- Investigating the reality of using virtual laboratories in light of the developments in educational technologies from the point of view of faculty members in some Saudi universities.
- Investigating the correlation between the total score of using virtual laboratories and the score of students' thinking skills from the point of view of faculty members in some Saudi universities.

Significance of the study:

The significance of the current study stems from the importance of the topic it deals with, which is the use of virtual laboratories from the point of view of faculty members in some Saudi universities, and to enhance the levels of scientific thinking among students. The significance of the study can be highlighted in the following:

First: theoretical significance:

The current study may contribute to revealing and enhancing the reality of using virtual laboratories from the point of view of faculty members in some Saudi universities.

- The current study may contribute to revealing and enhancing the reality of using virtual laboratories from the point of view of faculty members in some Saudi universities.
- The current study may contribute to defining the levels of scientific thinking among students from the point of view of faculty members in some Saudi universities in light of innovations in educational technologies, and enhancing these levels.
- The researcher hopes to enrich Arab libraries with more studies and related research in light of the paucity of previous studies in this context - as far as the researcher knows - .

Second: applied significance:

- The findings of the current studies may contribute to investigating the obstacles to using virtual laboratories from the point of view of faculty members in some Saudi universities and to come up with appropriate recommendations that enhance their use.
- The findings of the current study may help in conducting other studies in this field.

Study terms:

- **Virtual laboratories:**

Virtual laboratories are defined as: interactive educational computer programs that simulate scientific experiments, and can be used without an internet connection; They are usually effort- and time-saving, less expensive, and more secure and safe than real laboratories. (Belfaqih, 2020, p. 240)

The term virtual laboratories also refers to laboratories that use simulations, computerized models, and many other educational technologies in order to carry out activities and experiments that are conducted in traditional laboratories (Alderbashi, 2022).

The researcher defines virtual laboratories as: electronic laboratories that simulate laboratories in real life to conduct experiments and scientific research, but with less effort, cost, and risk.

- **Scientific thinking skills:**

Scientific thinking skills are the ability to identify and analyze phenomena and facts that occur based on data in the field to find solutions through a series of logical and systematic thinking processes (Prakasiwi & Ismanto, 2018).

Scientific thinking skills are also defined as: an organized method that depends on investigating the truth by following a number of steps or capabilities, and in a way that requires a certain level of accuracy in performance, starting with defining the problem, then choosing hypotheses and testing their validity, and the process ends with the ability to interpret and generalize the results, which are learnable skills and needs to be taken care of by educators and not just an innate predisposition to grow in a natural way. (Al-Shokri, 2016, p. 18)

The researcher defines scientific thinking skills as: the skills that every individual should possess to make his life easier and solve his problems, and those skills begin with observation, analysis, prediction, interpretation, and then developing solutions with which the problem can be solved and confronted.

- **Innovations of educational technologies:**

Innovations of educational technologies are defined as: A group of contemporary technological media that are used within educational institutions and their social, ethical and scientific effects, which can achieve a quantum leap in the education field, its ethics and patterns through good interaction between teachers and learners. (Al-Mujarreb, 2019, p. 52)

Innovations of educational technologies are also defined as: Employing technological means in the educational process; They are an integrated educational system to transfer learning in order to increase the performance of the teacher and student to deal with the educational process and solve problems, which combines several types of educational stimuli, to achieve specific educational goals (Ahmad, 2016).

The researcher also defines the innovations of educational technologies as: every modern means that is used in the educational process to develop and improve its outputs, and these include: computers, virtual laboratories, smart boards, mobile devices such as phones and iPads, and programs and software related to these technologies.

Theoretical framework:

The current era has witnessed great technological developments, which have had a strong and influential impact on societies. Technologies have become the dominant feature in all aspects of life; Rather, the progress of nations is measured by the technological progress they have reached in all their practical and theoretical fields. Technologies are no longer exclusively limited to some fields, as they are the common ground in all fields of our lives currently. (Sarhan, 2016, p. 407)

One of the most important technological applications recently introduced in educational institutions is virtual laboratory platforms, which have been able to cover a large part of teaching scientific thinking skills to students in universities. People have always known that a number of behavioral patterns are acquired through simulation and observational learning, as mentioned by Bandura in his theory of social learning when he mentioned that learning by observation is the source of creativity, as differentiation and divergent differences in the model lead to the emergence of new responses, and this is what appears clearly in dealing with virtual laboratories through various programs. (Hakami, 2023, p. 247)

Virtual laboratories relieve pressure on universities through the cost and maintenance of real laboratories, while benefiting from the vast technological knowledge of students in the current era. Properly planned and implemented virtual laboratories can advance students' knowledge, skills and test performance, while reducing constraints by geography, health, safety, cost and availability (Lynch & Ghergulescu, 2017, 1).

Interactive laboratories represent laboratories that create an interactive environment that simulates real-world science laboratories, with high technical specifications, and helps conduct experiments virtually using CDs and the Internet. They are an imaginary or artificial teaching and learning environment that is a substitute for reality, in which students can conduct laboratory experiments, and see the equipment, measuring devices, and various laboratory tools as if they were real. Mohammad, 2021, p. 440)

Hence, it turns out that virtual laboratories are very effective in developing students' academic achievement and their scientific thinking skills. Virtual laboratories are an effective tool in influencing students' acquisition of higher-order thinking skills. It is also noticeable that university institutions seek to introduce, activate and adopt virtual laboratories as one of the most important modern technological innovations that work to develop learners' scientific thinking skills, develop their imagination, galvanize, and attract them to courses in an interesting and motivating way.

Importance and advantages of using virtual laboratories:

There are many advantages of virtual laboratories, which are among the most important modern technological innovations in educational institutions, which save time and effort for the learner, as well as ensure his safety and security.

Implementing virtual laboratories in an active classroom environment ensures that all students have easy access to expensive hardware and software resources at their homes, and can save a significant amount of time especially for those exercises where the outputs are in the form of reports and prototypes; The implementation of virtual laboratories in higher education institutions can provide a global platform for students to learn and explore different options, and if a student is unable to attend the practical session for any reason, he can perform laboratory exercises from his home or from anywhere (Al Ajmi et al., 2017, 8675).

The virtual laboratories work on the learner's acquiring of self-learning skills that allow him the ability to ask questions and discuss issues in order to be able to keep pace with the permanent change of knowledge and information, and this in turn leads to what is called the independence of his learning, and the transfer of the learner from the realm of receiving information in theory to the realm of practical application, and providing distinguished educational material for the learner that makes him overcome the fear gap in the use of modern technological methods between the teacher and the learner, and the formation of positive behaviors and attitudes for the learner that enables him to realize and derive them from multiple sources. (Ghanem, 2023, p. 469)

There are also many advantages of virtual laboratories, including (Al-Janabi, 2015, p. 451):

1. They provide students with skillful experiences that are very close to direct experience, away from the danger caused by practicing some experiments in direct ways.
2. They eliminate the obstacles that prevent the practice of real experiments, such as the lack of devices, the factors of time and place, or the extreme accuracy of the studied material.
3. They increase students' ability to visualize concepts that are difficult to imagine realistically.
4. They provide an interesting scientific atmosphere and practicing the experiment step by step while providing feedback and the possibility of following up on the work accomplished by the students.
5. Through them, it is possible to replace some equipment that is difficult to provide in traditional laboratories, such as the electron microscope, which can study the composition and reproduction of bacteria and viruses, for example, in an interactive way without studying them using an electron microscope.

Hakami (2023, p. 249-250) explains that one of the advantages of virtual laboratories is the development of the principle of self-learning by practice among students. They are also an excellent alternative to traditional laboratories, as they provide skillful experiences for students; They also allow a great ability for the student to visualize many concepts that are difficult to imagine realistically, as well as providing safety from health, physical and environmental risks, and protecting the learner from the risks of practical training. They also contribute to overcoming the obstacles that prevent the practice of real experiments, as well as working to save effort, time and money than if we used traditional laboratories.

From the above, it can be said that the importance of virtual laboratories stems from the many facilitations they can provide in the educational process. Virtual laboratories allow students to enjoy learning experiences similar to real learning experiences, but modern technologies allow virtual laboratories to overcome the limitations of time and space, enhance the flexibility of learning processes, and the possibility of simulating phenomena immediately and realistically. Therefore, it is important to view virtual laboratories as an essential component of the educational process and not just an addition or improvement.

The reality of using virtual laboratories in modern university education:

Using virtual laboratories has become indispensable in contemporary reality in universities because of the many advantages provided by this type of laboratories, however, this type of technological innovation still faces some difficulties in its application and activation.

It was found that the reality of using virtual laboratories in contemporary university education varies with regard to the employment of virtual laboratories; Some enjoy their employment, some do not use them, and some are not convinced of them. And since the faculty member is one of the pillars of the educational process in the university, as he creates the climate that would develop the educational process, so knowing the extent to which professors employ virtual laboratory techniques in their teaching of courses is an important matter to facilitate and absorb the related courses. For example, in the Kingdom of Saudi Arabia, it was found that the rate of employing virtual laboratories had to a medium degree due to the high number of students, the lack of a sufficient number of computers, and the lack of copies of ready-made software, in addition to the lack of training in the use of virtual laboratories, and the lack of focus of practical activity books on performing experiments in virtual laboratories and focusing on real laboratory experiments. (Shehadeh, 2013, p. 228)

The study of (Hristova et al., 2021, 68), about the use of virtual laboratories in some Bulgarian universities, found that different forms of providing laboratory instruction were used for students, including written text instructions (PDF files, etc.), video instructions, and video conferences; And the findings showed that it was easy for students to understand virtual laboratory instructions by 86% and implement them by 72%, and that recorded video instructions were the preferred form to present the content of virtual laboratories, followed by video conferences and text materials.

When considering the reality of educational technologies in the Kingdom of Saudi Arabia it is realized that this field is in dire need of intensive and continuous development efforts, and given that the experiences of virtual classrooms in the universities of the Kingdom of Saudi Arabia are recent, the virtual classroom system is still in its early stages; It also needs more experiments, research and study.. (Al-Subaie, 2015, p. 49)

The Kingdom of Saudi Arabia seeks to activate the use of virtual laboratories in teaching natural courses in universities through: modifying university courses to allow a greater opportunity to apply the practical side of the courses through virtual laboratories by allocating lectures for practical application using virtual laboratory techniques, providing material requirements to activate the employment of virtual laboratories, working to develop the capabilities of faculty members to use virtual laboratories and employ them in teaching and learning processes through their professional development through (training courses - delegations - workshops and research groups), and educating learners about the importance of using virtual laboratories and their effectiveness in developing their achievement and skill capabilities, as well as establishing a bank of practical experiences based on virtual laboratory techniques that is made available to all parties in the educational process through the global information network (the Internet). (Sarhan, 2016, p. 425)

From the above, it is clear that the reality of using virtual laboratories in the field of university education is characterized by two main features: the first feature is the growing awareness of the importance of integrating this type of laboratory into educational environments in universities; The second feature is the high material, human and technical requirements for applying virtual laboratories in universities effectively. Hence the importance of managing and allocating the necessary resources for the successful adoption and application of virtual laboratories in the field of higher education as a whole.

Types of virtual laboratories:

The application of virtual laboratory is an experimental teaching method for virtual reality. Virtual laboratory depends on multi-media, the human-computer interaction, and network connection technology to build high simulation experimental environment, therefore, the organization of high-quality lab work is cost-effective for schools and universities, moreover, due to conducting experiments virtually, virtual laboratories are highly error-tolerant, which not only protects users from risk, but also opens a possibility to learn from mistakes (Ni et al., 2022, 678).

Virtual laboratories is a relatively recent term emerging from technological development and introducing technology into the education field and all fields; They rely on applying virtual reality, as Virtual Labs are applications of so-called Virtual Reality, and they are one of the innovations of educational technology, which is considered an artificial or imaginary educational environment replacing and simulating reality, where the learner lives in an imaginative environment which he interacts, participates and deals with through his senses and with the help of a computer and some assistive devices. (Ghanem, 2023, p. 470)

Virtual laboratories are interactive educational computer programs that simulate science experiments established in natural subjects, and can be used without an Internet connection. They are usually effort- and time-saving, less costly, and more secure and safe than traditional laboratories, such as the Crocodile program in chemistry, physics, and other programs. (Belfaqih, 2020, p. 240)

Virtual laboratories are divided into several types, including: virtual reality environments, simulations, remote virtual classes, and virtual classes inside classrooms.

- **Virtual reality environments:**

Universities as traditional institutions of higher education are increasingly enhancing the traditional classroom experience through open, web-based and blended forms of teaching and learning, for example, by integrating virtual learning environments into university education; These virtual environments have the potential to significantly change the learning environment, providing a number of advantages in terms of convenience and increased flexibility. One of the primary arguments for using virtual learning environments is to increase the amount of student control, because students need to make their own decisions about the pace, flow, or order of instruction (Stöhr et al., 2016, 664).

Virtual reality environments are a set of indicators and performances that contribute to building and evaluating environments based on a number of technologies and 3D multimedia so that they resemble or simulate a real educational situation. Virtual reality environments are characterized by the fact that they provide alternative experiences to real experiences that are difficult or impossible to acquire in real-world; They also provide education software in an attractive form that contains fun, entertainment, experience with information and control over it. In addition, virtual reality provides a scientific field for the speed of acquiring experiences, narrowing the gap between knowledge and its application, contributing to dropping the barriers of time, space and danger, helping students interact with others in remote places in non-traditional ways, transferring and representing the real world within the educational environment and enabling learners to interact with it. (El-Sayed, 2016, p. 581)

Virtual reality technologies seek to build environments based on codes, in order to simulate reality and create imaginary environments that have nothing to do with it; Rather, they are imaginary environments created by digitization and multimedia, in which the user engages to practice experiences that are difficult to practice in real-world, such as roaming space or wandering inside the furnace of an atomic reactor or travel back in time through geological ages; Virtual reality environment technologies aim to create an environment similar to reality in all its details and characteristics. This is represented in showing fixed and moving objects as if they are in their real world in terms of their embodiment, movement and sensation. Virtual reality environments are complementary to multimedia and work to create an environment with multiple sensory entry points. Virtual reality has certain characteristics that distinguish it from other computer media and educational methods such as interaction, learner control, cooperation, self-learning, direct manipulation; And virtual reality is an experience that a person goes through using a set of special tools, and this experience simulates a life situation. (Othman et al., 2017, p. 234)

- **Simulation:**

The virtual laboratories system is one of the important systems of obvious benefit, as it is distinguished compared to other educational means by its use of simulation of global phenomena, where students are able to find solutions to any problem they encounter in any experiment; Experiments and their simulation process are also one of the most important features of applying the computer system in teaching courses that require experiments. (Abu Hasel, 2016, p. 98)

Simulation is mathematical models that provide a quantitative and qualitative experience for each experiment, which compliments real laboratory practices and skills (Radhamani et al., 2015, 29). Integrating simulation in teaching and learning provides students with opportunities to reflect real-world ideas or environment, and simulation is also a technique to enhance learning and increase students' interest in and awareness of the subject being taught; and using simulation tools reduces the need for equipment and management costs compared to real practical teaching (Shimba et al., 2017, 47).

Thus, virtual laboratories are a learning environment that relies on a computer program in which the real laboratory is simulated so that learners can carry out experiments through it. It is a program for the Crocodile Clips Company, and it was localized by Majd Education Development Company. The trend towards using virtual laboratory technologies is one of the most prominent trends used in education, as learners can, through these technologies, prepare experiments in a safe interactive manner, which gives the learning and teaching process an interesting dimension that the needs to improve the level of understanding and interaction. (Sarhan, 2016, p. 411-412)

Simulation can be considered one of the most prominent areas that can be employed in natural science laboratories. Simulation is used by employing the computer with all its multiple capabilities to clarify a specific thing or to clarify a special skill. The computer provides the element of suspense and excitement of the learner by using multiple communication tools such as pictures, graphics and different sounds. This type is one of the widest types of computer use in conducting experiments and laboratory activities. The virtual laboratory is a laboratory that simulates the real laboratory, through which results similar to the results of the real laboratory are obtained. (Nail, 2018, p. 76)

- **Remote virtual classes:**

A remote virtual class is an online learning environment that may be web-based and accessible through a portal or software platform and requires a downloadable file; It allows participants to communicate with each other and view their presentations; The main characteristics of remote virtual classes are unlimited learning, ease of access, reasonable prices, flexibility according to the learner's need and time, and they are practical and proven (Biswas & Nandi, 2020, 334).

Virtual classes are one of the models of distance education, they it depend on the availability of computer, Internet, and the programs necessary to operate them for learners and teachers, through which the teacher can deliver information to the learner anywhere and at any time, and these classes allow interaction between teacher and learner, content, and colleagues, so that the learner can-by connecting to the Internet-enter the study hall, which is not a real hall and without walls, but there is a professor in it according to the schedule prepared to give a lecture or discuss with the students. (Al-Nafjan, 2018, p. 183-184)

Remote virtual classes are one of the electronic tools available in the Tadarus system under the name "Live Encounters", which provides an interactive environment based on the global information network "the Internet", enabling both the teacher and the learners to communicate effectively via video, audio, written dialogue, application sharing, and other electronic communication means that enable direct and interactive education. (Al-Subaie, 2015, p. 52)

Among the advantages of remote virtual classes is that they make the learner feel equal in dialogue, provide the learner with an atmosphere of privacy, develop his self-learning skills, help mastery learning, encourage cooperative learning, and meet the learner's needs, in addition to that, remote virtual classes reduce burdens on the educational administration, raise the learner's motivation towards learning, and help continuous education. (Al-Hassan & Ashabi, 2017, p. 60)

Virtual classes inside classrooms:

Synchronous virtual classrooms are digital classrooms that simulate traditional classrooms, where both the teacher and the learners are present on the Internet simultaneously without being restricted by space boundaries; The classroom allows the teacher to use various tools, techniques, and applications in explanation, and he can manage class discussions by interacting with learners while performing tasks, activities, and assignments, with the aim of providing them with information, concepts, and directions, and training them in basic skills. (El Bahnasawy, 2018, p. 97)

A synchronous virtual classroom allows faculty and students to interact online simultaneously; The best advantages of a synchronous online classroom are that faculty and students can talk to each other using text, audio, and video; And synchronous virtual classrooms provide faculty with the ability to know students' opinions on the spot and give students the opportunity to participate in group activities that they can interact with as if they were face to face, and these interactive elements are not available in the asynchronous model (Kaware, 2015, 3043).

Synchronous virtual classrooms, then, are classroom-like classrooms, characterized by their richness with various tools and technologies that increase the opportunities for training students and developing their various learning abilities and skills, and they require the presence of the teacher and the learner at the same time with no space limits. (Rabie, 2021, p. 1157)

Some of the advantages of synchronous virtual classrooms include:

1. They help develop research and information-seeking skills, and stimulate student motivation towards learning.
2. They help in employing modern teaching strategies, taking into account individual differences among learners.
3. They increase mutual interaction between the professor and students, and also help in providing reality simulation software.
4. They develop students' critical and creative thinking skills, and develop new mechanisms for practicing dialogue and listening skills.
5. They help consolidate scientific research and thinking skills, and help provide immediate feedback to students.
6. They give the learner a room for scientific freedom.

From the above, it is clear that it is possible to use virtual classrooms in several different forms in the field of university education. Despite the diversity of these forms, the thing they have in common is the use of virtual reality technologies to replace traditional educational environments in one way or another; Thus, it can be said that virtual laboratories can enrich learning experiences in the field of higher education.

The importance of scientific thinking skills for university students:

Scientific thinking skills are among the most important skills that all individuals should possess, not only because of their importance on the scientific level, but also because of their importance on the personal, social, practical levels and all aspects of life, because they facilitate the life of the individual, and make him able to coexist with his reality, accepting his problems and able to overcome them.

Scientific thinking skills refer to the basic competency of problem-solving skill, and they play an important role in developing students' higher-order thinking skills, in addition to affecting the logical and organized thinking of the student. In this regard, scientific thinking skills not only help the student in acquiring scientific knowledge, but also help him obtain accurate scientific observation, collect, classify and analyze data, and build correct scientific explanations (Al-Shamri, 2021, 3479).

Bani Ahmed (2015, p. 25) believes that scientific thinking leads to organized knowledge that is stored in memory and the formation of knowledge structures. It also leads to improving the level of acquisition, production and application of scientific concepts, and the formation of conceptual systems that form principles, generalizations and laws that facilitate problem-solving and decision-making. It also leads to an improvement in the level of achievement in courses; In this way, the development of scientific thinking skills requires all higher education institutions to make radical changes in their curricula, programs and teaching methods, and to increase their interest in developing students' intellectual skills and to teach and train them on scientific thinking skills and processes.

From the above, it can be said that the importance of scientific thinking skills is evident in helping the individual to think about the surrounding world and its prevailing phenomena in a more rational and comprehensive manner. These skills also make the individual more able to accept and absorb new knowledge and adapt to the continuous flow of knowledge. Therefore, scientific thinking skills are among the components for successful living in light of contemporary reality.

Types of scientific thinking skills:

Thinking is one of the higher mental processes that interfere with many other processes, and thinking takes many patterns. Psychologists have divided thinking skills into two levels, the lower and the higher, and they have distinguished between them as the existence of a basic set of skills that a person must possess, such as understanding and remembering, and then employing what he learned in his own style, not in the way he learned, and through application and through his personal analysis; And his innovation of a different method in which he presents the information he has acquired, but in his own way, he has reached higher thinking skills. (Al-Atrebi, 2020, p. 120)

Scientific thinking skills include some stages: inquiry, the process of defining the objectives of the activities, identifying the data and initial phenomenon, connecting the findings from the phenomenon to the initial knowledge which the students have already had, and formulating the problem; Analysis stage is a productive analysis that involves the processing, interpretation and presentation of data obtained from the previous stages; Inference, the conclusion stage in which products are produced from past activities; and Argument, the last stage where it is expected to include a process of expressing an opinion about fact and theory, presenting the different finding reached, refuting the theory that has been advanced, and maintaining the consistency of the statement given (Asmoro et al., 2021, 948).

There are many scientific thinking skills that every individual should learn and practice, which are: observing the problem, formulating hypotheses, information and evidence collection, evidence evaluation, drawing conclusions, and below each skill is dealt separately in some detail.

- **Observing the problem:**

Defining or observing the problem: scientific processes often result from a concrete problem, and these problems can be practical, for example, real-world problems, so the start of scientific thinking is an imperfect explanation of a particular phenomenon (Dorfner et al., 2018, 234). Problem observation also includes recognizing the inconsistency between a problem (from a scientific, professional, or factual context) and existing interpretations, analyzing the situation, and building a representation of the problem (Omarchevska et al., 2022, 240).

Observing the problem is a skill that is often used early in the thinking process, and it refers to the individual's ability to distinguish the question that contains the problem directly, and expresses it in a direct expression and not other than the questions asked, and it can include phrases such as: What is the problem? And who has this problem? And what makes it a problem?, or why should it be solved? The skill of observing the problem is a kind of challenge, because it needs accuracy in discovering the main issues that may hide under the details, and it begins when a person faces a problem, and the question becomes: What exactly is the problem?. (Al Shokri, 2016, p. 20-21)

Observation accompanies the problem in all its stages, as it is before, during and after the hypothesis, and leads to the formulation of hypotheses and theories, and is sometimes limited to the senses, and at other times requires means and tools that enable the elicitation of hypotheses, induction of theories, production of laws, and the verification of their validity or falsity. (Al-Idrisi, 2018, p. 180)

In order to develop the skill of observing problems among learners, the courses should focus on presenting scientific problems, and help learners to identify specific problems more than dealing with general problems, and should also help students to look at problems as a natural thing, and help them collect information about the problem , dealing with the problems they face in their daily lives, defining scientific problems clearly, and thinking about all aspects of the problem. (Bani Ahmed, 2015, p. 46)

- **Formulating hypotheses:**

It can be said that the process of formulating hypotheses consists of six steps: observing the situation; generating a causal question; question analysis; representation of the phenomena experienced; representation of causation; and building hypotheses (Zelechowska et al., 2020, 2). Formulating hypotheses also involves building possible answers to a question (according to scientific standards) based on known models, frameworks, or evidence, e.g. an evidence-based suggestion of a substance that influences how the memory of honey bee evolves (Opitz, 2016, 165).

Hypothesis is an expression generally used to refer to a possibility or initial conclusion or an unproven saying that is subject to examination and experimentation in order to reach a reasonable answer or result that explains the ambiguity surrounding a situation or problem; and hypotheses are formulated in the form of a testable and declarative sentence. (Behery, 2022, p. 42)

The skill of formulating hypotheses is represented in setting hypotheses first: which expresses the ability to choose one of the solutions to the problem existing in the situation that is encountered by differntiating between a number of available hypotheses that appear to be possible solutions to the problem, then testing the validity of the hypotheses: which expresses the ability to choose the most appropriate ways to test the validity of the hypothesis among a number of ways that seem possible to test the validity of the hypothesis posed by the given situation. (Bani Ahmed, 2015, p. 7-8).

- **Drawing conclusions:**

Drawing conclusions is a cognitive process that focuses on coordinating and evaluating inquiry processes and past findings, however, it means more than a process of coordinating two cognitive processes such as generating hypotheses and evidence assessment that are central to evaluating evidence; Drawing conclusions often involves integrating different evidence by considering the methods by which the evidence was generated in addition to the cognitive standards of the discipline(s) in question in order to infer something, for example, the applicability of a tool such as the learning environment or the characteristics of the original problem (Csanadi, 2017, 21).

Drawing conclusions requires the individual to think beyond the information available to him, and analyze it in order to identify relationships between things and concepts and compare them to each other. (Mostafa, 2013, p. 49)

Drawing conclusions means choosing the alternative that achieves the best results in light of the established criteria and the desired purposes. In this step, the decision-maker chooses the alternative that he believes is superior to other alternatives in that it is the least costly, the most useful, and the fastest in implementation, and the necessary human resources are available for its implementation. The decision-maker should formulate the conclusion accurately so that those in charge of implementation can understand it correctly, and know what is required of them to implement the decision. (Mohammad, 2015, p. 234)

From the above, it has been shown that various scientific thinking skills help the individual deal and adapt to the surrounding world in various forms in order to obtain new knowledge and information, and scientific thinking; Of course, none of these skills is sufficient by itself, but rather it is important that they are used in conjunction with other skills in an integrated manner, as these skills provide inputs and outputs to each other.

Scientific thinking characteristics:

The room for thinking for man represents a spacious field through which he draws his vision of the future and the factors that help him achieve his goals, and thinking for a person is like a map from which he chooses the ways to help him with the work that achieves his goals and invests his time; Scientific thinking is different from other types of thinking in that it directly links man with his mental activity, and it does not require physical effort; And perhaps one of the most important characteristics of scientific thinking is that it stems from sensory experience, but it is not confined or limited to it; It is also a reflection of the correlations between phenomena, events and things in a verbal symbolic form, in addition to that it depends on the integration and organization of previous experiences. (Al-Atrebi, 2020, p. 118-119)

Scientific thinking can be conceptualized as using a set of mental rules, plans or strategies to devise causal inferences about a phenomenon beyond direct observation; In short, it is about thinking skills to understand observable phenomena to infer unobservable mechanisms; In essence, scientific thinking is related to causal inferences, whereby individuals make use of a reference of strategies or rules to align evidence with theoretical hypothesis (Ding et al., 2016, 621-622).

Scientific thinking features many characteristics, as it can be developed in students by training them to think and be sensitive to problems, and to create new alternatives. Also, scientific thinking extends over time, as it relates to the past in which the problem occurs, the present in which the individual searches for alternatives to solve the problem and it also looks forward to the future in which he will make the decision and evaluate the results of the decision; Scientific thinking is an integrated series of sub-skills that correspond and overlap with each other to define the problem, analyze, discover its aspects, collect information about it, and choose the best results to solve it. (Mohammad, 2015, p. 235)

There are many characteristics of scientific thinking, which are: objectivity and rationality, verifiability, organization and systematicity, accuracy and explicability; and during the following section we will address each characteristics separately.

- **Objectivity and rationality:**

Rationality is the ability to explain reasons and arguments using evidence for ideas and beliefs; Rationality and objectivity are the primary focus in the use of appropriate evidence and logical arguments used to connect ideas and evidence (Alfiana & Wiyarsi, 2023, 4).

Objectivity is a value, and there are two fundamentally different ways of understanding objectivity: According to product objectivity, science is objective in that it is, or to the extent that, its products—theories, laws, empirical results, and observations "facts"—form accurate representations of the external world; According to process objectivity, science is objective in that, or to the extent that, the processes and methods that characterize it do not depend on contingent social and moral values, nor on the individual bias of the scientist (Reiss & Sprenger, 2014, 4).

The scientific truth is objective in the sense that all specialists participate in perceiving it, and it is not exclusive to some of them, on the pretext that they have a sixth sense that they enjoy exclusively, or they have insight that they are unique to, or that they perceive facts with their hearts before their minds, and other such statements that we do not want to accuse of lying because they may be completely truthful statements in their field, but despite that they are not considered scientific thinking, because they lack the characteristic of objectivity that allows everyone who wants, and whoever has a sufficient amount of achievement and training to review the ideas put forward to verify their scientific truth. (Mahmoud, 2019, p. 26)

- **Verifiability:**

One of the most important characteristics of scientific thinking is that the information that the individual obtains to confront any problem is verifiable, through the fact that the information is original, that is, the data and information contained therein can be verified, and that it is possible to verify the validity of all that is stated in it. (Dashly, 2016, p. 87)

The verifiability criterion asserts that a piece of knowledge or intellectual project is considered meaningful only when it passes the test of empirical verification or is explicable by definition, and the verifiability criterion proposes that the significance, validity, and truthfulness of a statement can only be inferred from the possibility of stating the facts that make it possible (Adesina, 2021, 2).

Organization and Systematicity:

Systematicity refers to the tendency to organize, arrange, focus, and diligence in any investigation; Priority is not given to any specific type of thinking or action (i.e., linear or non-linear), rather, an organized, systematic individual seeks to deal with specific issues, inquiries, and problems in an organized and focused manner (Memiş, 2016, 68).

One of the most important characteristics of scientific thinking is organization and methodology, that is, we do not let our thoughts flow freely, but we arrange them in a specific way, organize them consciously, and make an intentional effort to achieve the best possible planning for the way we think. In order to reach this organization, we must overcome many of our common daily habits, and we must get used to subordinating our thinking to our conscious will, and focusing our minds on the subject we are looking at, all of which are arduous matters that need special training, and they are refined by continuous practice. But if science is a regulation of our way of thinking or our method of rational practice, then it is at the same time - a regulation of the external world, that is, in science we are not limited to organizing our inner life only, but also the world surrounding us, because the world is full of intertwined and overlapping events, and we must in Science is to extract from this entanglement and complexity a set of

facts that interest us in our own field, and these facts do not come to us ready-made, and do not occupy a separate part of the world labeled "chemistry" or "physics". Rather, our task in science is to carry out this organization from which we can pick out from the complex whole that interests us in our own field. (Zakaria, 2018, p. 22)

- **Accuracy and explicability:**

This means that the results of scientific thinking can be demonstrated at all times and places. There are some phenomena that are difficult to subject to testing, due to the difficulty of doing so or the confidentiality of the information related to them. This characteristic also means the need to collect that quantity and quality of accurate information, which can be documented, and which helps researchers and thinkers to test it statistically, and analyze its results in a scientific and logical way, in order to ascertain the validity or invalidity of hypotheses and results; It should be noted here that the accurate and correct information that is collected, and whose results are analyzed in a correct and systematic way, increases the degree of confidence of individuals when making their various decisions. (Dashly, 2016, p. 37)

This process occurs when the individual explains, simplifies, or interprets one or more pieces of information for himself or for others in order to reveal its meaning or ambiguity so that it becomes accessible to understanding. Explanation may be used with appropriate explanation tools such as: giving examples, using similes or illustrations such as drawings, images, paintings, etc. (Behery, 2022, p. 40)

From the above, it is clear that scientific thinking skills have several characteristics that differ from other thinking skills, as scientific thinking combines interest in abstract ideas and concrete matters; Therefore, employing scientific thinking skills helps the individual to extract new information based on what was collected and analyzed from preliminary data and evidence. Hence, it can be said that scientific thinking skills are not only useful in performing scientific practices and activities, but also help in adapting and coexisting with the factors of surrounding environments, which are characterized by their constant and rapid change.

Correlation between using virtual laboratories and developing scientific thinking skills:

Technological innovations in general have led to many positive results in educational institutions, and in particular, virtual laboratories have worked on developing the scientific thinking skills of learners because of their many advantages that enrich scientific content and make it simulate reality without causing any damage. Indeed, virtual laboratories have enabled learners to repeat experiments again and again without leading to an increase in material costs or the trouble and effort for the learners.

Therefore, the courses, if they want to contribute to the development of scientific thinking, one of the most important issues that should be taken into account is that they are designed and implemented in ways that call for the launch of learners' ideas, challenge their creativity and stimulate their motivation towards innovation. It should also be based on scientific foundations through which it appears to save time, effort, and the element of safety for students, and provide an opportunity to present learning in an interesting way. Among the academic courses are the courses related to scientific experiments, which are difficult to apply in traditional laboratories; Therefore, it is necessary to provide laboratories that apply the experiment in a semi-sensory way. Hence, it was necessary to have laboratories that simulate traditional laboratories and that can carry out all experiments in the least time and with the least possible effort; And here came the role of virtual laboratories, which greatly contributed to achieving the objectives of scientific courses and developing scientific thinking skills among university learners. (Al-Zahrani, 2020, p. 984)

The virtual laboratories work on developing scientific thinking skills through: Covering all course ideas with interactive experiments, which is difficult to achieve through the real laboratory due to the limited capabilities, space and time available for practical work. Also, the virtual laboratories provide synchronization between the process of explaining theoretical ideas and practical application, as laboratory experiments The real thing is linked to a laboratory schedule separate from the theoretical lectures, and the availability of laboratory experiments for learners at all times and from anywhere, in addition to the possibility of conducting the

experiment for any possible number of times according to the learner's ability to comprehend and the right time for him, and the ease of conducting various experiments and studying their impact on the outcome of the experiment through virtual control panels, and allowing interaction and collaboration with others to conduct the same experiment remotely. (Al-Fatli, 2021, p. 187)

The virtual laboratory can explicitly organize the inquiry structure and explain to students to help them model the scientific process, and let them create their own inquiry map to guide the inquiry process; This has been found to have a long-term effect on students' scientific knowledge. On the other hand, the virtual laboratory can enhance scientific thinking strategies and skills explicitly through questioning; This form of aid involves proactively providing contextualized instructions according to students' situation in the virtual laboratory. Thus, the students focus on the important aspects of the scientific problem (Liu et al., 2022, 306).

In applications of virtual laboratories in areas such as biology, biotechnology, and chemistry, virtual laboratories have been found to be an effective complementary tool that supports classroom teaching, and has positive effects on knowledge, scientific thinking skills, problem-solving, critical thinking, and student motivation (Fadda et al., 2022, 59).

Al-Riyamia & Al-Najjar (2020, pp. 300-301) believe that virtual laboratories allow learners to explore freely, interact with events and phenomena flexibly, and learners can evaluate their performance through the feedback they provides, and they can also repeat watching the event or phenomenon, that is, virtual laboratories control their learning process, and thus through them, learners can reach a deeper understanding of abstract concepts that are difficult to reach through traditional laboratories, and they can also form a better perception of events and phenomena around them.

Al-Haidari & Al-Dalah (2021, p. 187) believe that the use of virtual laboratories has contributed to the reprogramming of education and the diversity of its methods and the development of scientific thinking skills, especially the discovery strategy, in addition to what these laboratories provide in terms of increasing the effectiveness between the learner and the educational content, the teacher and the learner, so that learning becomes more exciting and fun.

Al-Masaeed & Abu Zina (2013, p. 111-112) show that virtual laboratories have a positive impact on the development of scientific thinking skills for learners, as the use of virtual laboratories increases their chances of making any change that comes to mind in the values of current or voltage difference without fear of Cautions that may cause any malfunction in the devices or danger to their lives, and this in turn can be a new beginning for the growth of science fiction among the learners as a result of roaming the experiences of the imaginary worlds of virtual situations better than the learners who study in traditional laboratories.

Shenaq (2021, p. 76-77) also explains that the effectiveness of virtual laboratories in developing scientific thinking skills is due to the fact that the use of multimedia technologies in presenting content worked to address the senses of the learner, and that the virtual laboratory is based on the principle of individualizing education and meeting the individual differences of learners, and the virtual laboratory contains experiments, information and activities, and the use of Methods different from those that occur in the usual laboratory rooms, all of this led to the enrichment of the laboratory skills of the learners; Also, the educational software based on the techniques of the virtual laboratory overcame many of the obstacles of the traditional laboratory, as it crossed the boundaries of time and space, thus allowing students to learn anytime and anywhere, and education through virtual laboratories helped learners overcome the factor of fear and dread that some learners may get while dealing with traditional lab tools, as virtual laboratories allow learners to use lab tools without fear, with the possibility of using them more than once.

From the above, it has been shown that the use of virtual laboratories may be an effective way to develop scientific thinking skills among university students. The use of these laboratories helps to stimulate the student's senses during learning, and thus learning becomes multi-modal rather than being limited to a specific pattern such as the audio, visual or text pattern. In addition, the simulation capabilities and other various interactive capabilities encourage the student to use various mental skills in learning processes, including scientific thinking skills; Therefore, it can be said that the use of virtual laboratories contributes to the development of the integrated scientific mindset among university students.

Previous studies:

Gul's study (2022) explored the impact of the experiment of employing teaching based on scientific research on developing students' scientific thinking skills and life skills. The study population consisted of members of the schools participating in the implementation of the scientific research project implemented by Faisal Husseini Foundation in the schools of East Jerusalem, and the sample included (20) individuals who were divided into: two female principals, five female teachers, ten students and three officials. The study relied on the analytical descriptive qualitative research design as its approach, and used the interview and the questionnaire as the study instruments. The study reached many findings, the most important of which are: the success of the scientific research employment experiment in developing scientific thinking skills and life skills among students; and revealing the obstacles that affected the success rate of employing this experiment, related to the qualification of the teaching staff, the students' conviction and motivation, the non-acceptance of some parents of the idea, and their lack of cooperation in involving their children in the experiment, in addition to the relatively limited success in some subjects, and less limited success in others, despite the fact that most of the educational materials were subject to this experience.

Al-Talhi's study (2021) also worked to investigate the role of virtual laboratories in developing creative thinking skills, to reveal the level of creative thinking skills among students of the Faculty of Science at Taif University, and to find whether there is a statistically significant correlation between the use of virtual laboratories on the development variable of creative thinking skills in its various dimensions (fluency, flexibility, originality, elaboration, and sensitivity to problems). The study population consisted of female students in the Faculty of Science at Taif University, and the sample included (112) female students; The study relied on the descriptive correlative research design as its approach, and used the questionnaire as the study instrument. The study reached many findings, the most important of which are: that the students who used the virtual laboratories have better creative thinking skills than those who did not use them; there is a positive correlation between the use of the virtual laboratories and the development of creative thinking skills; in addition to the statistically significant differences between the students' responses about developing their creative thinking skills due to the use of virtual laboratories.

Mohammad's study (2021) addressed the reality of using virtual laboratories at the University of Maysan from the point of view of faculty members. The study population consisted of faculty members who teach the practical aspect in real laboratories at the University of Maysan, and the sample included (50) male and female teachers; The study relied on the descriptive research design as its approach, and used the questionnaire as the study instrument. The study reached many findings, the most important of which are: the lack of internet service at the university and its unavailability to faculty members and students in particular; It has been found that virtual laboratories do not take into account the issue of saving effort and time for teachers, as they need effort to get to know the appropriate software, the way to design it, operate it, and make it available to everyone, and this requires additional teaching time; In addition, there are no obstacles when dealing with virtual laboratories, as they do not pose any danger when using them, and they are also safe when conducting dangerous experiments in front of students, such as dealing with radioactive materials and chemical and nuclear reactions.

The study of Al-Zahrani (2020) also aimed at: investigating the effectiveness of the virtual laboratory in developing scientific thinking skills (observation – comparison – synthesis – interpretation) among sixth-grade students in Al-Baha region, as well as revealing the significance of the differences between the mean scores of students who study in the usual way and those who study in the traditional laboratory or in the traditional classroom to test some scientific thinking skills (observation – comparison – synthesis – interpretation). The study population consisted of a group of sixth-grade students in Al-Baha schoold district in the Kingdom of Saudi Arabia, and the sample included (80) students; The study relied on the quasi-experimental design as its approach, and used the scientific thinking skills test as the study instrument. The study reached many findings, the most important of which are: There are statistically significant differences at the significance level (0.05) between the mean scores of the students of the experimental group (who studied using the virtual laboratory) and students of the control group (who studied in the traditional laboratory) in the post-application of the test for the skills of observation, comparison, synthesis and interpretation in favor of students of the experimental group; There are also statistically significant differences at the significance level (0.05) between the mean scores of the experimental group students in the pre and post applications of the test for some scientific thinking skills (observation – comparison – synthesis – interpretation) in favor of the post application; In addition, the use of the virtual laboratory in teaching science achieved an effect size in developing some scientific thinking skills (observation – comparison – synthesis – interpretation) among sixth-grade students in Al-Baha region.

The study of Al-Shehri (2018) aimed to present a proposal for designing a virtual laboratory in the development of scientific thinking in the physics course among secondary school students in Al-Baha region, and to know the impact of using virtual laboratories on scientific thinking among third-grade secondary students in physics. The study population consisted of all third year secondary school students in Al Makhwah Governorate for the academic year 1438-1439 AH, and the sample included (30) students; The study relied on the descriptive and semi-experimental designs as its two approaches, and used the scientific thinking test and the SPSS program as instruments. The study reached several findings, the most important of which are: There are statistically significant differences at the significance level (0.05) between the mean scores of the students in the pre and post applications of the scores of the scientific thinking skills test in favor of the post application, and this result is attributed to the experimental treatment (using the virtual laboratories); The virtual laboratories software also has a significant impact on the development of scientific thinking in physics among third year secondary school students, this is due to the ability of virtual laboratories to simplify information and theoretical concepts for learners, and to present educational content in an attractive manner that adds a lot of fun, entertainment, and excitement; They also make learners feel as if they are in a real laboratory, which makes them deal with tools faster; In addition, the nature of the educational design used for the virtual laboratory software took into account all the learners' educational needs, as well as the educational objectives of physics.

The study of (Alshaikh, 2022) investigated the reality of using virtual laboratories in teaching advanced biology curricula in developing higher-order thinking skills among secondary school students. The study population included all biology teachers in public secondary schools in Al-Kharj Governorate, Saudi Arabia, and the sample consisted of (54) female teachers; The researcher relied on the analytical descriptive design as the study approach, and used the questionnaire as the study instrument. The study reached several findings, the most important of which are: female teachers enjoy a (high) level of awareness of the importance of using virtual laboratories to develop higher-order thinking skills; Teachers' use of virtual laboratories to develop higher-order thinking skills to a (medium) level; There are statistically significant differences in the responses of the sample members according to the variable of number of training workshops on virtual laboratories; And the most significant obstacles for female teachers to use virtual laboratories include: large number of students, increased working hours and administrative tasks, lack of equipment needed for virtual laboratories, lack of Arabic-based virtual laboratory programs, insufficient teaching time, low student motivation, etc.

The study of (Raja et al., 2021) aimed to investigate the effectiveness of teaching the virtual laboratory in developing higher-order thinking skills among engineering students, and comparing the higher-order thinking skills that are developed through the Virtual Innovation & Research Acceleration Lab (VIRAL), and the traditional method. The study population consisted of all students of the SRM Institute of Science and Technology in India, and the sample included (98) students divided into (49) students in the experimental group and (49) in the control group; The researchers used the quasi-experimental research design as a study approach, and used tests as a study instrument. The study reached several findings, the most important of which are: the application of the virtual laboratory improves students' higher-order thinking skills to a (high) degree; the application of the virtual laboratory improves scientific, logical, analytical and critical thinking among students to a (significant) degree; there are statistically significant differences between the sample members in the post-test of analyzing research and innovation skills, in favor of the experimental group; and there are statistically significant differences between the sample members in the post-tests of higher-order thinking skills, in favor of the experimental group.

The study of (Cameila & Ferris, 2017) investigated a review of findings about the emotional involvement of undergraduate students in the use of scientific thinking skills; The study population consisted of all students in the field of systems engineering at (30) universities in Australia, Indonesia and the United States, and the study sample included (163) students; The study relied on the descriptive analytical method based on the questionnaire. The findings of the study included the following: The perceptions of the study sample towards engaging in the use of scientific thinking skills were positive to a (high) degree, and there were no statistically significant differences between the study sample in the level of engagement in scientific thinking skills, in terms of the gender variable.

(Huang et al., 2015) conducted a study that aimed to investigate the levels of scientific thinking skills among undergraduate engineering students. The study population consisted of all students in the years between the first and the third participating in four educational courses in an engineering college in the United States, and the sample included (117) students; The study relied on the analytical descriptive approach based on the scientific thinking questionnaire and the systems engineering diagnosis activity questionnaire. The findings of the study included the following: Scientific thinking skills were (high) among the study sample; there was a positive correlation between the results of the scientific thinking questionnaire and the results of the systems engineering diagnosis activity questionnaire; and there were no statistically significant differences between the responses of the study sample in terms of the gender variable.

The study of (Radhamani et al., 2014) analyzed the role of virtual laboratories for biotechnology in integrating students' learning ability and presenting it as an effective educational tool in biotechnology courses; The study population consisted of all biotechnology students at Amrita University in India, and the sample included (100) students; The researchers relied on the case study design as the study approach, and used the questionnaire and tests as study instruments. The study reached several findings, the most important of which are: the (high) level of ease in students' adaptation to the use of virtual laboratories; the application of virtual laboratories affects student performance and learning ability to a (high) degree; and that virtual laboratories improve the level of the active learning process to a (high) degree.

Study hypotheses:

The study hypotheses were formulated after the researcher reviewed the theoretical framework and previous studies as follows:

- The levels of students' scientific thinking skills do not vary in light of the developments in educational technologies from the point of view of faculty members in some Saudi universities.
- The reality of using virtual laboratories in Saudi universities does not vary in light of the developments in educational technologies from the point of view of faculty members in some Saudi universities.
- There is no statistically significant correlation at the significance level (0.05) between the total score of using virtual laboratories and the score of students' scientific thinking skills from the point of

view of faculty members in some Saudi universities.

Methodological procedures of the study:

Study approach:

The current study will follow the analytical descriptive design as the study approach, which is "one of the forms of organized scientific analysis and interpretation to describe a specific phenomenon or problem and depict it quantitatively by collecting data and specific information about a phenomenon or problem, classifying, analyzing, and subjecting it to careful study" (Abdul Momen, 2008: p. 287)

Study population and sample:

The current study population included (1100) faculty members in some Saudi universities; The study sample included (285) faculty members, to represent the study population.

Characteristics of the study sample:

The frequencies and percentages of the study sample individuals were calculated according to (gender - years of experience - number of training courses).

1- Distribution of respondents according to gender:

Table (1) Distribution of respondents according to gender

s	Gender	Frequency	Percentage
1	Male	185	64.9%
2	Female	100	35.1%
Total		285	100.0%

Table (1) shows that (64.9%) of the respondents are males, while (35.1%) of the respondents are females.

2- Distribution of respondents according to the number of years of experience:

Table (2) Distribution of respondents according to years of experience

s	Years of experience	Frequency	Percentage
1	Less than 5 years	77	27.0%
2	From 5 to 10 years	62	21.8%
3	10 or more	146	51.2%
Total		285	100.0%

Table (2) shows that (27.0%) of the respondents have less than 5 years of experience, while (21.8%) of the respondents have 5-10 years of experience, while (51.2%) of the respondents have experience of 10 years or more.

Distribution of respondents according to number of training courses:

Table (3) Distribution of respondents according to number of training courses

s	Number of training courses	Frequency	Percentage
1	None	26	9.1%
2	Less than 3	52	18.2%
3	3 or more	207	72.6%
Total		285	100.0%

Table (3) shows that (9.1%) of the respondents do not have any training courses, while (18.2%) have less than (3) courses, and (72.6%) have less than (3) courses.

Study instrument:

After reviewing the educational literature and previous studies related to the subject of the study, the researcher built and developed a questionnaire with the aim of investigating the reality of using virtual laboratories and its relationship to students' scientific thinking skills in the light of innovations in educational technologies from the point of view of faculty members in some Saudi universities.

Description of the study instrument (questionnaire):

In its final form, the questionnaire contained two main parts:

The first part: includes the primary data of the sample, which is (gender – years of experience – number of training courses).

The second part: includes the axes of the questionnaire. In its final version, the questionnaire consisted of (25) statements distributed over two axes:

The first axis: "students' scientific thinking skills in light of the innovations in educational technologies" and consists of (15) statements distributed over three main dimensions.

The second axis: "The reality of the use of virtual laboratories in Saudi universities in light of innovations in educational technologies" and consists of (10) statements.

A five-point Likert scale (very high - high - medium - weak - very weak) was used to investigate the reality of using virtual laboratories and its relationship to students' scientific thinking skills in light of innovations in educational technologies.

Validity of the study instrument:

1) **Validity of internal consistency of the study instrument:**

a) **Validity of internal consistency of the questionnaire axes**

The validity of the internal consistency was calculated according to the responses of the sample, by calculating the Pearson correlation coefficient between the scores of each statement and the total score of the axis to which the statement belongs, as the results are shown in Table (4) following; Pilot sample = (30):

Table (4) Pearson correlation coefficients between the scores of each statement and the total score of the axis to which the statement belongs

The first axis: "students' scientific thinking skills in light of the innovations in educational technologies, from the point of view of faculty members in some Saudi universities"					
Item no.	**Correlation coefficient**	**Item no.**	**Correlation coefficient**	**Item no.**	**Correlation coefficient**
1	.721**	6	.589**	11	.739**
2	.777**	7	.649**	12	.882**
3	.892**	8	.635**	13	.819**
4	.884**	9	.810**	14	.926**
5	.832**	10	.812**	15	.813**
The second axis: "The reality of the use of virtual laboratories in Saudi universities in light of innovations in educational technologies from the point of view of faculty members in some Saudi universities"					
1	.688**	5	.809**	9	.890**
2	.891**	6	.845**	10	.897**
3	.909**	7	.845**		
4	.935**	8	.479**		

**** statistically significant at significance level (0.01)**

*** statistically significant at significance level (0.05)**

Table (4) shows that the correlation coefficients of the statements with the total degree of the axis to which the statement belongs were all statistically significant at the significance level (0.01); All the values of the correlation coefficients were high, as they ranged in the first axis: "Students' scientific thinking skills in light of innovations in educational technologies from the point of view of faculty members in some Saudi universities" between (.589**-.926**); As for the second axis: "The reality of using virtual laboratories in Saudi universities in light of the innovations in educational technologies from the point of view of faculty members in some Saudi universities", the correlation coefficients ranged between (.479**-.935**). This indicates the high degree of validity of internal consistency in the statements of the questionnaire axes.

b) Construct validity of the questionnaire axes:

The construct validity of the questionnaire axes was verified by finding correlation coefficients between the total score for each axis and the total score of the questionnaire, and the results are shown in the following table:

Table (5) Correlation coefficients between the total score for each axis and the total score for the questionnaire axes

s	Axis	Correlation coefficient
1	**The first axis:** "students' scientific thinking skills in light of the innovations in educational technologies, from the point of view of faculty members in some Saudi universities"	.969**
2	**The second axis:** "The reality of the use of virtual laboratories in Saudi universities in light of innovations in educational technologies from the point of view of faculty members in some Saudi universities"	.918**

**** statistically significant at significance level (0.01)**

Table (5) shows that the values of the correlation coefficients for the axes of the questionnaire with the total score of the questionnaire were high, as they ranged between (.918**-.969**), and they were all statistically significant at the level of (0.01); Which indicates the high degree of construct validity for the axes of the questionnaire.

Reliability of the study instrument:

Table No. (6) Cronbach's alpha reliability coefficients for the axes of the questionnaire

s	Axis	No. of items	Cronbach' alpha coefficient
1	The first axis: "students' scientific thinking skills in light of the innovations in educational technologies, from the point of view of faculty members in some Saudi universities"	15	.957
2	The second axis: "The reality of the use of virtual laboratories in Saudi universities in light of innovations in educational technologies from the point of view of faculty members in some Saudi universities"	10	.983
Total		25	.961

Table (6) shows that the values of the reliability coefficients for the questionnaire axes were high, as the values of the coefficients ranged between (.957-.983), and the value of the total reliability coefficient for the questionnaire axes was (.961); These values of reliability coefficients indicate the validity of the questionnaire for application and the reliability of its results.

Discussion of study findings:

- **Discussion of the first hypothesis: "The levels of students' scientific thinking skills do not vary in light of the innovations in educational technologies from the point of view of faculty members in some Saudi universities.**

To answer the second question, the arithmetic mean and standard deviation were calculated for each dimension of the first axis, and then those dimensions were arranged in descending order based on the arithmetic mean, as shown in the following table (7):

Table (7) Frequencies and arithmetic mean to illustrate "students' scientific thinking skills in light of innovations in educational technologies from the point of view of faculty members in some Saudi universities."

s	Dimension	Arithmetic mean	Standard deviation	Axis rank	Response degree
1	First dimension: observing the problem	3.46	.834	1	High
2	Second dimension: formulating hypotheses	3.31	1.140	2	Medium
3	Third dimension: drawing conclusions	3.10	.998	3	Medium
Total score of the first axis		3.29	.933	---	Medium

Table (7) that "the degree of possessing scientific thinking skills among students in light of innovations in educational technologies from the point of view of faculty members in some Saudi universities" was (medium) from the point of view of the respondents, as the total mean for the first axis was (3.29) with a standard deviation of (.933); The standard deviations of the questionnaire axes ranged between (.834-1.140): In the first place came the first dimension: observing the problem with a mean of (3.46) and a standard deviation of (.834), followed by the second dimension in the second place: formulating hypotheses with a mean of (3.31) and a standard deviation of (1.140), and in the last place, the third dimension: drawing conclusions with a mean of (3.10), and a standard deviation of (.998).

The researcher believes that the degree of scientific thinking skills among students in light of innovations in educational technologies from the point of view of faculty members in some Saudi universities has a medium response degree from the point of view

of the sample: it may be attributed to the need for more training for students to develop scientific thinking skills, and to conduct more training and practice of educational technologies with the aim of providing students with these skills, which contributes to increasing their ability to achieve higher levels of scientific thinking skills.

This finding disagrees with the finding of the study of (Huang et al., 2015), which concluded that the students' scientific thinking skills came to a (high) degree among the study sample.

- **Discussion of the second hypothesis: "The reality of using virtual laboratories in Saudi universities does not vary in light of the innovations in educational technologies from the point of view of faculty members in some Saudi universities.**

To answer this question, the arithmetic mean and standard deviation were calculated for each of the statements of "The reality of using virtual laboratories in Saudi universities in light of the innovations in educational technologies," and then the statements were arranged in descending order based on the arithmetic mean, as shown in the following table (8):

Table (8) Frequencies, percentages, arithmetic means, and standard deviations of the respondents' for "the reality of using virtual laboratories in Saudi universities in light of innovations in educational technologies from the point of view of faculty members in some Saudi universities".

Statement			Response degree					Mean	Standard deviation	Statement rank	Response level
			Very weak	Weak	Medium	High	Very high				
10	The Internet is used in virtual laboratories to increase scientific research skills	f	0.0	0.0	99	76	110	4.04	.857	1	High
		%	0.0	0.0	34.7	26.7	38.6				
3	The university management provides the technological means and devices needed for the use of virtual laboratories	f	24	0.0	102	99	60	3.60	1.082	2	High
		%	8.4	0.0	35.8	34.7	21.1				
8	The laboratories provide opportunities for students to acquire the skills of observation, accurate recording, and fact-based reasoning	f	38	25	87	50	85	3.42	1.350	3	High
		%	13.3	8.8	30.5	17.5	29.8				
7	The university provides trainers with a high level of professionalism and efficiency to train faculty members in the use of virtual laboratories	f	25	37	100	50	73	3.38	1.241	4	Medium
		%	8.8	13.0	35.1	17.5	25.6				
9	Motivation is stimulated among students through the use of technological media in virtual laboratories	f	38	25	73	88	61	3.38	1.283	5	Medium
		%	13.3	8.8	25.6	30.9	21.4				
6	The university provides specialized technicians to repair hardware and computer malfunctions in	f	37	25	88	87	48	3.29	1.227	6	Medium
		%	13.0	8.8	30.9	30.5	16.8				

	virtual laboratories										
5	The university provides the suitable budget to continuously develop and update the devices and technological means in the virtual laboratories	f	50	25	89	73	48	3.15	1.304	7	Medium
		%	17.5	8.8	31.2	25.6	16.8				
2	Virtual laboratories facilitate integrated performance by faculty members in explaining their courses and conducting practical experiments accurately	f	63	12	86	75	49	3.12	1.367	8	Medium
		%	22.1	4.2	30.2	26.3	17.2				
1	Virtual laboratories are used to achieve effective communication and cooperation between faculty members and students	f	49	25	100	74	37	3.09	1.246	9	Medium
		%	17.2	8.8	35.1	26.0	13.0				
4	The university provides the appropriate infrastructure to achieve the goal of virtual laboratories	f	101	48	62	37	37	2.51	1.416	10	Weak
		%	35.4	16.8	21.8	13.0	13.0				
The total mean of the second axis: "The reality of using virtual laboratories in Saudi universities does not vary in light of the innovations in educational technologies from the point of view of faculty members in some Saudi universities.								3.30	.899	---	Medium

Table (8) shows that the "reality of using virtual laboratories in Saudi universities in light of innovations in educational technologies" came with a (medium) degree from the point of view of the faculty members of the sample, as the total mean for the second axis was (3.30) with a standard deviation of (.899), and the values of the standard deviations for the expressions of the second axis ranged between (.857-1.416).

In the first place came the statement no. (10) (the internet is used in virtual laboratories to increase scientific research skills) with a mean of (4.04), and a standard deviation of (.857), followed in the second order by statement no. (3) (the university management provides the means and the technological devices needed to use the virtual laboratories) with a mean of (3.60), and a standard deviation of (1.082), while in the last place came statement no. (4) (the university provides the appropriate infrastructure to achieve the goal of virtual laboratories) with a mean of (2.51) and a standard deviation of (1.416).

The researcher believes that after using the Internet in the virtual laboratories in Saudi universities in light of the innovations in educational technologies, it has been classified as (medium) from the point of view of the study sample, and this is due to the many obstacles that may prevent the ability of some faculty members to use the virtual laboratories as required and providing students with scientific skills and appropriate methods of thinking; the reason may be the poor training in the use of devices and modern technological means available in the virtual laboratories for students.

This finding disagrees with what was indicated by the finding of Huang et al. (2015), which concluded that the scientific thinking skills of undergraduate students came with a (high) degree.

Discussion of the third hypothesis: "There is no statistically significant correlation at the level of (0.05) between the total score of using virtual laboratories and the score of students' scientific thinking skills from the point of view of faculty members in some Saudi universities.

To answer this question, Pearson's correlation coefficient was calculated between the total score of the two axes of the questionnaire; The results of the analysis were as shown in the following table:

Table (9) The results of the Pearson correlation coefficient between the total score of using virtual laboratories and the score of students' scientific thinking skills from the point of view of faculty members in some Saudi universities.

Dimensions of scientific thinking skills	The total score of using virtual laboratories	
	Correlation coefficient	Statistical significance
First dimension: observing the problem	.841**	.000
Second dimension: formulating hypotheses	.803**	.000
Third dimension: drawing conclusions	.863**	.000
Total score of scientific thinking skills	.885**	.000

The results of Table (9) indicate the following:

There is a positive correlation between the total score of using virtual laboratories and the score of scientific thinking skills of students from the point of view of faculty members in some Saudi universities, which reached (.885**); This indicates that the more virtual laboratories used in Saudi universities, the more that students will possess scientific thinking skills.

The researcher believes that this result may be due to the important role that virtual laboratories play in providing students with scientific thinking skills, including observing the problem, formulating hypotheses and drawing conclusions, and its ability to consolidate information in their minds, and facilitate referring to information at anytime and anywhere.

This finding is consistent with the findings of many previous studies, including the findings of the study of (Raja et al., 2021), which confirmed the presence of statistically significant differences between respondents, in the post-tests of research analysis and innovation skills in favor of the experimental group, and the presence of statistically significant differences between respondents in the post-tests of higher-order thinking skills, in favor of the experimental group.

This finding is also consistent with the findings of the study of (Radhamani et al., 2014), which confirmed that the application of virtual laboratories affects the performance of biotechnology students at Amrita University in India and their learning ability to a (high) degree, and that virtual laboratories improve the level of active learning process to a (high) degree.

Summary of findings:

This is represented by presenting the most important findings of the study regarding answering its questions and achieving its goals, as follows:

- "The level of scientific thinking skills among students in light of innovations in educational technologies" came to a (medium) degree.
- In **the first place** came **the first dimension**: observing the problem with a mean of (3.46) and a standard deviation of (.834), followed by the second dimension in the second place: formulating hypotheses with a mean of (3.31) and a standard deviation of (1.140), and in the last place, the third dimension: drawing conclusions with a mean of (3.10), and a standard deviation of (.998).
- "The reality of using virtual laboratories in Saudi universities in light of innovations in educational technologies among students" came with a (medium) degree from the point of view of faculty members in some Saudi universities.
- There is a positive correlation between the total score of using virtual laboratories and the score of students' scientific thinking skills from the point of view of faculty members in some Saudi universities, as it reached (.885**).

Study recommendations:

- The need for university administrations to design an organizational structure within the university that promotes the use of virtual laboratories.
- Paying attention to instilling and strengthening the concepts and dimensions of scientific thinking among students.
- Working on developing and updating means and technologies in virtual laboratories with the aim of enhancing the learning process and delivering information easily and smoothly to university students.
- The need for Saudi university students to acquire the skills of inclination to reflect deeply, the ability to conduct scientific research, and curiosity.
- The need for faculty members to be keen on providing students with the skills of aligning innovative idea with the prevailing values in society and with their previous experiences.
- Providing material and moral incentives to creative university students to increase their levels of commitment to developing and enhancing their scientific thinking skills.

References:

Abu Hasel. Badria Saad Mohammad. (2016). The reality of the requirements for using virtual laboratories in teaching science from the point of view of middle school science teachers and supervisors and their attitudes towards them in the Kingdom of Saudi Arabia. *Journal of Education – Al-Azhar University*, *1* (170), 94-144. http://search.mandumah.com/Record/864546

Al Mahfouz, Mohammad Zidan Abdullah. (2020). The degree of practicing virtual classes by faculty members at the College of Education, King Khalid University in light of the Corona pandemic, and its relationship to creative teaching skills. *King Khalid University Journal of Educational Sciences*, *7*(2), 279-333. http://search.mandumah.com/Record/1133746

Al-Atrebi, Sherif Mohamed. (2020). *E-learning and 21st century skills - modern education tools and strategies*. Al-Arabi for Publishing & Distribution.

Al-Idrisi, Rabia Al-Omrani. (2018). Among the features of scientific thinking in Arabic grammar: Sibawayh's book and the characteristics of Ibn Jinni, two examples [paper presentation]. Proceedings of the International Symposium: The Centrality of Ibn Jinni in the Arabic Linguistic Study, Abdelmalek Essaâdi University - Faculty of Arts and Humanities, Morocco.

El Bahnasawy, Abeer Abdel Halim. (2018). The use of synchronous virtual classrooms in developing some teaching competencies among students teachers of biological sciences, at the Faculty of Education, Tanta University. *Journal of the Faculty of Education, 29* (116), 89-146.

Al-Janabi, Tariq Kamel Dawood. (2015). Employing virtual laboratories in developing science processes among fifth science students and their attitudes towards biology. Anbar University Journal of Human Sciences, 2, 441-476.

Al-Hassan, Issam Idris Kamtoor, & Ashabi, Hana Awad Mohammad Naqd. (2017). The reality of using of virtual classrooms in distance learning programs from the point of view of faculty members: Sudan Open University as a model. *Association of Arab Universities Journal for Education and Psychology, 15* (1), 45-75. http://search.mandumah.com/Record/847351

Al-Haidari, Anfal Ghazi, & Al-Dalah, Osama Mohammad Amin. (2021). The effectiveness of different patterns of augmented reality in cognitive achievement and the development of metacognitive thinking skills among secondary school students in the chemistry course during the spread of Covid-19 virus in Medina. *The Arab Journal of Specific Education, 5* (19), 177-238.

Al-Riyamia, Basmaa bint Hamad bin Ali, & Al-Najjar, Noor bint Ahmed. (2020). The effectiveness of using virtual reality in developing achievement and visual thinking skills of tenth grade female students in the Sultanate of Oman in social studies subject. *Educational Journal - Kuwait University, 34* (137), 291-336.

Al-Zahrani, Salih Abdul-Majid Ali. (2020). The effectiveness of the virtual laboratory in developing scientific thinking skills among sixth grade students in Al-Baha region. *Journal of the College of Education - Mansoura University*, (110), 981-1023.

Al-Subaie, Al-Jawhara bint Fuhaid bin Walid. (2015). Evaluating the use of virtual classrooms in distance education programs: Imam Mohammad Ibn Saud Islamic University as a model. *Journal of Faculty of Education - Benha University, 26* (103), 45-82.

El-Sayed Mohammad El-Sayed Mohammad. (2016). Standards for the development of virtual reality environments in light of the quality of e-learning programs. *Journal of the College of Education*, (20), 570-592. http://search.mandumah.com/Record/882966

Al-Shukri, Muftah Mohammad Abd Al-Rahman. (2016). Scientific thinking skills between learning and teaching. *Educational Journal - El-Merqib University*, *8*, 6-32.

Al-Shehri, Asmaa Ali Zafer. (2018). A proposal to design a virtual laboratory for the development of scientific thinking in the physics course for secondary school students in Al-Baha region. *Journal of the Faculty of Education - Assiut University, 34* (8), 174-207.

Al-Talhi, Manal bint Abdulaziz bin Ali. (2021). The role of virtual laboratories in developing creative thinking skills among students of the College of Science at Taif University [unpublished master's thesis]. Taif University.

Al-Fatli, Hussein Hashem Handoul. (2021). *E-learning and virtual education - educational technologies in the third millennium within the framework of professional practice quality standards (frameworks - skills - strategies)*, Dar Al-Wefaq for publishing & distribution.

Al-Mujarreb, Khaled Khalifa Musaed Eid Khalifa. (2019). Teachers' attitudes towards professional ethics in the field of education in light of technology innovations and their impact on middle school education students in the State of Kuwait. *Culture and Development, 19*(140), 45-70.

Al-Masaeed, Jawdat Ahmed, & Abu Zina, Awwad Mohammad Khair. (2013). The effect of using virtual laboratories on both achievement and scientific imagination of Jordanian university students in their field of study of physics. *Educational Journal - Kuwait University, 27* (106), 79-121.

Al-Nafjan, Najla Ibrahim. (2018). The reality of using virtual classrooms in distance education to teach preparatory year courses for female students at King Abdulaziz University in Jeddah. *Journal of Reading and Knowledge, 196*, 181-237. http://search.mandumah.com/Record/847168

Behery, Hanadi Mohammad. (2022). Scientific Thinking in Literary Criticism: Standards and Skills. *Al-Hikma Journal for Literary and Linguistic Studies, 1*, 30-68.

Belfaqih, Salih Abdullah Hassan. (2020). Obstacles to the use of virtual laboratories among teachers of natural sciences at the secondary stage in Mukalla. *Al-Rayyan Journal of Humanities and Applied Sciences, 3*(2), 237-272.

Bani Ahmed. Ruwaida Musa. (2015). Scientific thinking skills included in the content of the science curriculum for the lower basic stage and the extent to which students acquire them [unpublished master's thesis]. Al AlBayt University.

Hakami, Al-Seif Abu Shamla Othman. (2023). Virtual laboratories are a successful alternative in the achievement of students of scientific subjects at the secondary level. *Arab Journal for Measurement & Evaluation, 4*(7), 247-252. http://search.mandumah.com/Record/1354237

Dashly, Kamal. (2016). Scientific research methodology. Directorate of University Books and Publications.

Rabie, Iman Hamed Mahmoud. (2021). The effectiveness of using synchronous virtual classrooms in teaching the course of implementing outerwear and the attitude of students towards it to face the quarantine due to the Corona virus. *Journal of Research in the Fields of Specific Education, 32*, 1149-1182. http://search.mandumah.com/Record/1109120

Zakaria, Fouad (2017). *Scientific Thinking*. Hindawi Foundation CIC.

Sarhan, Mohammad Omar. (2016). The effectiveness of virtual laboratories in the achievement of third-grade middle school students in Riyadh, Saudi Arabia. *Educational Sciences - Cairo University, 24*(1), 405-429.

Shehadeh, Fawaz Hassan Ibrahim. (2013). The extent to which science teachers employ virtual laboratory techniques in their teaching of science courses at the secondary level in the Kingdom of Saudi Arabia. *Education Journal - Al-Azhar University, 3* (156), 222-247. http://search.mandumah.com/Record/863249

Shenaq, Majid Kamal Mohammad. (2021). Designing educational software based on virtual laboratory techniques to develop laboratory skills in chemistry among secondary school students in Amman. *Al-Andalus Journal, 8*(32), 59-84.

Othman, Al-Shahat Saad Mohammad, Atallah, Hamida Nabih Al-Desouki, & Masoud, Suhair Hamdi Faraj Hassan. (2017). The skills needed to develop educational virtual reality environments for students of educational technologies. *Educational Technologies 27*(1), 233-272.

Ghanem, Yasmine Ibrahim. (2023). The effect of using the virtual laboratory strategy on the achievement of the first cycle students in science and the retention of the learning effect. *The Arab Journal of Specific Education*, (26), 461-488.

Gul, Hanadi Salah Hamdan. (2022). An analytical and critical study according to the experience of employing teaching based on scientific research in developing students' scientific thinking skills and life skills [unpublished master's thesis]. Birzeit University, Palestine.

Mohammad, Amal Gomaa Abdel-Fattah. (2015). *Thinking skills - a contemporary educational vision*. University Book House.

Mohammad, Shaima Jassim. (2021). The reality of using virtual laboratories at Maysan University from the point of view of teachers. *Maysan Journal of Academic Studies, 20* (41), 436-450.

Mahmoud, Zaki Naguib. (2019). *The foundations of scientific thinking*. Hindawi Publishing Foundation.

Center for Developing University Education "Author". (2017). Technological innovations in the development of education. *Studies in University Education - Ain Shams University*, (35), 630-639.

Mostafa, Mostafa Nemr. (2013). *Development of thinking skills*. Dar Albedayah publishers & distributors.

Nail, Bashir Nail Taha. (2018). Obstacles facing physics teachers and limiting their use of virtual laboratories in teaching. *Journal of Educational Sciences - Sudan University of Science and Technology*, *19* (2), 76-86.

Adesina, O. I. (2021). Reviewing Modern Scientific Knowledge within the Scope of Nietzseche's Irrationalism. *Aquino Journal of Philosophy, 1*(1), 20-30.

Ahmad, A. A. F. (2016). *The Employment of The Technological Innovations in the Educational Process*. A paper presented at the 2nd Sriwijaya University Learning and Education (SULE) International Conference, Sriwijaya University, Palembang, Indonesia.

Al Ajmi, A., Al Badai, N., & Naidu, V. R. (2017 November 16-18). *Virtual Laboratories: The Future of active Learning of Practical Modules in Higher Education*. A paper presented at the 10th annual International Conference of Education, Research and Innovation (ICERI), Seville, Spain.

Alderbashi, K. Y. (2022). Attitudes of Teachers and Students in Private Schools in UAE towards Using Virtual Labs in Scientific Courses. *Multilingual Academic Journal, 7*(3), 406-425.

Alfiana, N., & Wiyarsi, A. (2023). Students' Scientific Habits of Mind from the Perspective of Educational Levels and Gender. *American Institute of Physics Conference Series, 2556*, 1-5.

Alshaikh, A. A. N. (2022). The Reality of Using Virtual Labs in Teaching Advanced Biology Curricula in Developing Higher-Order Thinking Skills (HOTS) among Female Teachers at Secondary Level in Al-Kharj. *Education Research International, 2022*, 1-12.

Al-Shamri, L. B. A. A. (2021). The Effect of the 5PBL Model in the Development of Scientific Thinking Skills and Academic Perseverance in Physics among First-grade Secondary School Students. *Ilkogretim Online, 20*(5), 3479-3496.

Ambusaidi, A., Al Musawi, A., Al-Balushi, S., & Al-Balushi, K. (2018). The Impact of Virtual Lab Learning Experiences on 9th Grade Students' Achievement and Their Attitudes Towards Science and Learning by Virtual Lab. *Journal of Turkish Science Education, 15*(2), 13-29. https://doi.org/10.12973/tused.10227a

Asmoro, S. P., Suciati, S., & Prayitno, B. A. (2021). Empowering Scientific Thinking Skills of Students with Eifferent Scientific Activity Types through Guided Inquiry. *International Journal of Instruction, 14*(1), 947-962.

Biswas, R. A., & Nandi, S. (2020). Teaching in Virtual Classroom: Challenges and Opportunities. *International Journal of Engineering Applied Sciences and Technology, 5*(1), 334-337. https://www.ijeast.com/papers/334-337,Tesma501,IJEAST.pdf

Camelia, F., & Ferris, T. L. J. (2017). Undergraduate Students' Engagement with Systems Thinking: Results of a Survey Study. *IEEE Transactions on Systems, Man, and Cybernetics: Systems, 47*(2), 1-12.

Csanadi, A. (2017). *Solving Professional Problems Together: The impact of Collaboration on Pre-Service Teachers' Scientific Reasoning* [Unpublished Doctoral dissertation]. Ludwig Maximilian University of Munich

Ding, L., Wei, X., & Mollohan, K. (2016). Does Higher Education Improve Student Scientific Reasoning Skills?. *International Journal of Science and Mathematics Education, 14*, 619-634. DOI 10.1007/s10763-014-9597-y

Dorfner, T., Fortsch, C., Germ, M., & Neuhaus, B. J. (2018). Biology instruction using a generic framework of scientific reasoning and argumentation. *Teaching and Teacher Education, 75*, 232-243. https://doi.org/10.1016/j.tate.2018.07.003

Fadda, D., Salis, C., Vivanet, G. (2022). About the Efficacy of Virtual and Remote Laboratories in STEM Education in Secondary School: A Second-Order Systematic Review. *Journal of Educational, Cultural and Psychological Studies (ECPS Journal)*, (26), 51-72. https://dx.doi.org/10.7358/ecps-2022-026-fadd

Gunawan, G., Suranti, N. M. Y., Nisrina, N., & Herayanti, L. (2018). Students' Problem-Solving Skill in Physics Teaching with Virtual Labs. *International Journal of Pedagogy and Teacher Education, 2*, 87-96. https://www.researchgate.net/publication/329548537_Students%27_Problem-Solving_Skill_in_Physics_Teaching_with_Virtual_Labs

Hristova, T., Gabrovska-Evstatieva, K., & Evstatiev, B. (2021). Prediction of engineering students' virtual lab understanding and implementation rates using SVM classification. *Journal of E-Learning and Knowledge Society, 17*(1), 62-71. https://doi.org/10.20368/1971-8829/1135420

Huang, S., Muci-Kuchler, K. H., Bedillion, M. D., Ellingsen, M. D., & Degen, C. M. (2015, October 21-24). Systems thinking skills of undergraduate engineering students. A paper presented at the 2015 IEEE Frontiers in education conference (FIE), El Paso, Texas, USA.

Kaware, S. S. (2015). Use of Virtual Classroom Software for Teaching. *Scholarly Research Journal of Interdisciplinary Studies, 3*(17), 3040-3047.

Liu, C. C., Chang, H. Y., Chang, M. H., Lai, P. H., Chiang, S. H. F., Yang, C. W., & Hwang, F. K. (2022). Augmenting the effect of virtual labs with "teacher demonstration" and "student critique" instructional designs to scaffold the development of scientific literacy. *Instructional Science, 50*, 303-333. https://doi.org/10.1007/s11251-021-09571-4

Lynch, T., & Ghergulescu, I. (2017, March 6-8). *Review of Virtual Labs as the Emerging Technologies for Teaching STEM Subjects*. A paper presented at the 11th International Technology, Education and Development Conference, Valencia, Spain.

Memiş, E. K. (2016). The Effects of an Argument-Based Inquiry Approach On Improving Critical Thinking and the Conceptual Understanding of Optics among Pre-Service Science Teachers. *International Journal of Progressive Education, 12*(3), 62-77. https://ijpe.inased.org/files/2/manuscript/manuscript_213/ijpe-213-manuscript-150646.pdf

Ni, J. L., Li, J. R., Xu, D. J., Yu, Y. P., & Wang, Q. H. (2022). A development platform prototype for virtual laboratories. *Computer Applications in Engineering Education, 30*(3), 678-689. https://doi.org/10.1002/cae.22480

Omarchevska, Y., Lachner, A., Richter, J., & Scheiter, K. (2022). It takes two to tango: How scientific reasoning and self-regulation processes impact argumentation quality. *Journal of the Learning Sciences, 31*(2), 237-277. https://doi.org/10.1080/10508406.2021.1966633

Opitz, A. (2016). *Advancing the Assessment of Scientific Reasoning Skills: A Review of Tests and a Detailed Analysis of a Common Test* [Unpublished Doctoral dissertation]. Ludwig Maximilian University of Munich

Prakasiwi, R., & Ismanto, B. (2018). Efforts to Improve Scientific Thinking Skills Through Application Discovery Model-Based Learning Environment Around. *Journal of Educational Science and Technology, 4*(3), 151-158. http://dx.doi.org/10.26858/est.v1i1.6047

Radhamani, R., Sasidharakurup, H., Kumar, D., Nizar, N., Achuthan, K., Nair, B., & Diwakar, S. (2015, November 19-20). *Role of Biotechnology Simulation and Remotely Triggered Virtual labs in Complementing University Education*. A paper presented at the International Conference on Interactive Mobile Communication Technologies and Learning (IMCL), Thessaloniki, Greece.

Raja, K., Duela, J. S., Duraipandian, Rajan, S., & Sathiyanarayanan, M. (2021, November 22-25). *VIRAL: The Effectiveness of Virtual Lab Teaching in Developing Higher Order Thinking Skills*. A paper presented at the 1st Conference on Online Teaching for Mobile Education (OT4ME),

Reiss, J., & Sprenger, J. (2014). Scientific Objectivity. *The Stanford encyclopedia of philosophy*. 1-62.

Shimba, M., Mahenge, M. P. J., & Sanga, C. A. (2017). Virtual labs versus hands-on labs for teaching and learning computer networking: A comparison study. *International Journal of Research Studies in Educational Technology, 6*(1), 43-58. https://doi.org/10.5861/ijrset.2017.1660.

Stöhr, C., Demazière, C., & Adawi, T. (2016, October 27-28). *Comparing Student Activity and Performance in the Classroom and a Virtual Learning Environment*. A paper presented at the 15th European Conference on e-Learning (ECEL), Prague, Czech Republic.

Zelechowska, D., Zyluk, N., & Urbanski, M. (2020). Find Out A New Method to Study Abductive Reasoning in Empirical Research. *International Journal of Qualitative Methods*, *19*, 1-11.